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Tracking Error of Equity Exchange-Traded Funds: Analysis from the European Markets

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Bachelor's Thesis

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Abstract

This paper examines the magnitude of tracking error and how based on size which is reflected by assets under management as a criterion affect the tracking error values in the European listed exchange-traded funds (ETFs). The findings show that a few ETFs are affected by a significant tracking error but overall there is no evidence of systematic significant tracking error of researched European ETFs. Evidence suggests that the size of the ETF does not affect the magnitude of tracking error and thus it should not affect the tracking ability of ETFs following their benchmark indexes.

Keywords: Exchange-traded funds; Tracking error; Magnitude; Assets under management

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1. Introduction

Exchange-traded funds' (ETFs) first appearance was in 1993 with the Standard and Poor´s Depositary Receipts (SPDRs), which track the S&P 500 and what is listed by American Stock Exchange (AMEX). The first ETFs in European market were listed on the German market in 2000 tracking the Stoxx Europe 50 and the Euro Stoxx 50(see e.g. Pope & Yadav, 1994; Poterba & Shoven, 2002; Ben-David et al., 2012). After that ETFs have become a big part of the investors toolkit and the market has continuously experienced rapid growth since the introduction of these products. According to equity research company ETFGI (2016) European ETFs' assets under management (AUM) is roughly 529 billion dollars within 1571 assets and in U.S. 2290 billion dollars AUM with 1680 products. Globally making 3206 billion dollars and 4785 ETF products totally[1].

As the industry itself has grown, so has the variety of exchange-traded funds available. ETFs have become increasingly popular because they have significantly lower transaction costs than the actively managed mutual funds (see e.g. Poterba & Shoven, 2002; Kostovetsky, 2003). Furthermore, ETFs represent a portfolio of securities designed to track the performance of an index, offering an efficient way to investors in obtaining cost-effective exposure. (see for example Frino & Gallagher, 2001; Chu, 2011.) When the objective of an ETF is to replicate the return and risk of the underlying benchmark index and if is not able to do it perfectly, this fund is regarded as unable to meet its investment objective. This difference between the returns of the ETF and its target index is called as tracking error. Thus, the level of tracking error may be an important criterion to assess an index fund performance because fund`s differential return may imply that if the manager´s investment process has been implemented successfully. Hence, tracking error is one of the investors key factor to compare before investing in ETFs. (see e.g. Roll, 1992; Pope & Yadav, 1994, Poterba & Shoven, 2002.)

Previous studies have found evidence about magnitude of tracking errors. First study of passive ETFs performance, made Gruber (1996), documents that US S&P 500 index funds underperforms the benchmark index by approximately 0,202%. For example, Frino & Gallagher (2001 and 2002)

[1] The data of the ETFs is collected from the website: http://etfgi.com/index/home.

has examined US and Australian index funds and found significant level of tracking error too. Later Chu (2011) investigates Hong Kong traded ETFs and found similar results. Moreover, Elia (2012) studied how the replication method affect the level of tracking error in the European traded ETFs and notice that ETFs following synthetic replication strategy hold a lower tracking error and higher tax efficiency.

The purpose of this thesis is to test whether there is inefficiency about ETFs ability to replicate the returns of its target benchmark index. Hence, to test the magnitude of tracking error in European listed ETFs each ETF separately and together the whole 35 ETFs in the sample only focusing on stock indexes. Besides, I split the whole sample half for two subsamples to examine if the ETF size based on AUM as a criterion affect the level of tracking error. I hence use and replicate the same methods that for example Frino & Gallagher (2001) and Marco Elia (2012) have previously used in their studies to get my results. I use four different measures to evaluate the tracking error and calculate the descriptive figures for each ETF separately, for whole sample and for small and large size ETFs based on AUM. I calculate the figures throughout the sample period since October 2008 to September 2016 and on yearly basis by using monthly data.

My results contradict a bit for the previous studies as I did not find any significant evidence of the magnitude of tracking error by examining each ETF separately (see e.g. Gruber, 1996; Frino & Gallagher, 2001; Shin & Soydemir, 2010; Chu, 2011). I find a few ETFs, which tracking errors differs from zero significantly but overall I did not find systematic significance considering the whole sample. In the other part of the research I calculated descriptive figures on the whole observation period and on yearly basis and when comparing the difference in means of tracking error for the small and larger size of ETFs I did not either find any kind of significances based on t-statistics.

In this paper the second section go over the markets, structure and characteristics of ETFs deeper and then move forward to examine the definition and previous literature of tracking error concluding with two hypotheses. The third section consists of data sample and the four measures how I calculate the tracking errors. The fourth section go through the results of the two tests and the fifth final section concludes the thesis.

2. Literature Review and Hypotheses

2.1 ETF Structure, Characteristics and Markets

Before ETFs, individual investors investing options were limited and most of the assets went to open-end and closed-end mutual funds or directly in individual stocks (Petäjistö, 2016). Nowadays ETF sector is a very serious challenger to the existing mutual fund industry exceeding over $3 trillion in AUM around the world at the first quarter of 2016. Those assets were listed on 64 distinct exchanges throughout 51 countries and extend across over 270 providers. However, the global market is leading by three providers: BlackRock Inc.`s iShares, Vanguard`s ETFs and State Street Global Advisors` SPDR ETFs managing nearly 70% of all ETF assets. The market is very dominated by these three since the next largest provider does not manage even 3,5% of the global market. Besides, the United Stated is the largest national domicile for ETFs and merely U.S.-based ETFs managed $2,15 trillion corresponding to 71,5% of global ETF assets. (ETFGI LLP, 2016)[2].

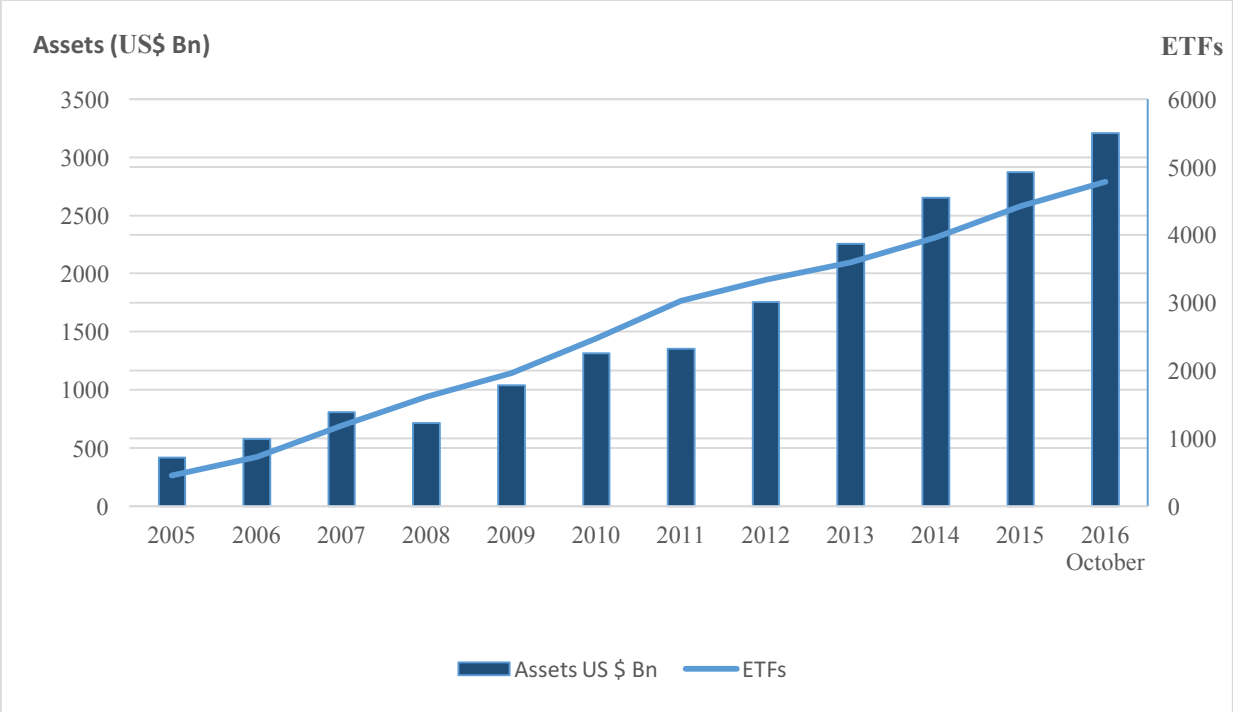

Figure 1a. The size of the ETF sector in the world. This figure shows the number of ETFs each year and their total market capitalization since January 2005 to October 2016.

[2] All the ETF information in this page are collected from the ETFGI's website: http://etfgi.com/index/home.

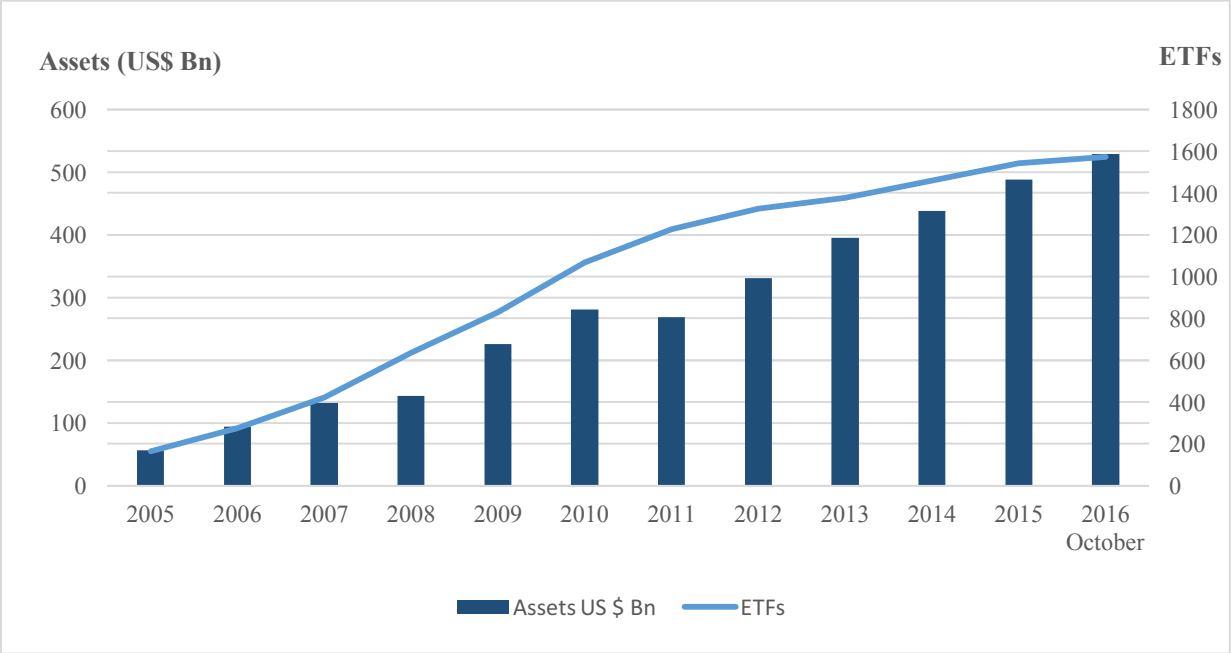

Figure 1b. The size of the ETF sector in the Europe.

ETF is an investment fund that can trade like common stocks on stock exchanges. ETF tracks some specific index, bonds, commodities or a basket of assets like a mutual fund (see e.g. Kostovetsky, 2003; Tripathi and Garg, 2016). It also owns the underlying assets e.g. equities and divides ownership of those assets into shares. Since ETF trades at stock market, its net asset value (NAV) has not calculated once at the end of every day. Its price fluctuates every time when they are bought or sold and thus changes throughout the day (see for example Gastineau, 2004). From the shareholders' point of view, they indirectly own the assets of ETF and hence they do not have any direct claim to the underlying investments in the fund. However, ETF shareholders' have their rights to a proportion of the profits. In case if the fund is liquidated they may get a residual value of the profits, such as dividends paid or earned interest. (Ben-David et al., 2012; Tripathi & Garg, 2016.)

There are various of reasons behind the popularity of ETFs and costs is the one. The average expense ratio for U.S non-leveraged stocks of ETFs is 0.44% according to Morningstar Investment Research. Their structure keeps cost low: with ETFs, you buy existing shares that an institutional

investor known as authorized participant has already created minimizing transaction costs (e.g. Kostovetsky, 2003). The second thing is the opportunity to do intraday trading as mentioned before. In addition, ETFs can be more tax-friendly as well: they rarely distribute capital gains because of the process of creation/redemption in-kind (Kostovetsky, 2003). They can be bought on margin or sold short and they can all be purchased easily on the investor´s brokerage account. (Petäjistö, 2016.)

In this paper I focus only on ETFs that track European stock indices so they follow only a specific stock index as closely as possible (see e.g. Kostovetsky, 2003; Gastineau, 2004; Agapova, 2011). Through an Index ETF, investors have the chance to own a well-diversified indexed portfolio with a help of using economies of scale to buy large quantities of stock at low cost (Poterba & Shoven, 2002). So in a one transaction investors will get exposure to a large number of securities. Most of the Index ETFs have a passive investment strategy. That´s why it is easier for Index ETFs track their benchmarks since they only make portfolio changes when changes occur in the underlying index. (see for example Agapova, 2011; Ben-david et al., 2012.) Although, there is still tracking error existing in Index ETFs according to previous literature.

2.2 Tracking Error

Tracking error means the difference between the returns of target index and ETF, which tracks the target index (see e.g. Gruber, 1996; Aber et al., 2009). Tracking errors can be used to evaluate the performance of ETFs and they are crucial in structuring and managing index funds. Tracking error exists because of the performance of an ETF is not guaranteed to be identical to the underlying benchmark index since an index is not subject to the same market policies faced by ETFs. Thus, index only represents a calculation derived from a portfolio of stocks. (Chu, 2011.) Usually the tracking errors of ETFs have been quite small, about few tenths of percentage. Nonetheless, due to variety of factors, tracking errors could have been over several percentage points between the ETF and its target index in the past (see e.g. Morningstar, 2013)[3].

[3] Typical tracking error numbers of ETFs collected from the Morningstar ETF Research report 2/2013. http://media.morningstar.com/uk/MEDIA/Research_Paper/Morningstar_Report_Measuring_Tracking_Efficiency_in_ETFs_February_2013.pdf

Multiple studies have investigated the causes of tracking error before this paper. In previous literature, Frino and Gallagher (2001) discuss the main factors of tracking error and how these affect the size of it. According to them, transaction costs, index composition changes, dividends, benchmark volatility, fund cash flows and corporate activity are the main factors causing tracking error on index ETFs. In real life, lots of market indexes are market capitalization weighted. Hence, index fluctuates for every amount of each security what it held according to the ratio of its market capitalization against the total market capitalization of all securities. When the market capitalization is market price times shares outstanding, the composition of indexes changes constantly because of the fluctuations in the price of securities. (See for example Ben-David, 2012; Angelini, 2013.) Further, theoretically whenever investor do transactions for an index ETF, all of these different securities have to be executed simultaneously at the current market price. Even though these trades are automated, ETF index fund can hold hundreds or thousands of securities and thus transactions at least slightly change the prices of the securities when trading.

Previous academic researchers have been focusing on US and Australian markets primarily. In their texts Frino and Gallagher (2001, 2002) and Elton et al. (2002) got documented significant tracking errors generated by index funds and ETFs. In early 2000s, researchers compare the return of the ETFs and the corresponding index return (see e.g. Elton et al., 2002; Harper et al., 2006). As like Frino and Gallagher, Kostovetsky (2003) also analyzed the factors that impact the tracking error of ETFs and index funds. Pope and Yadav (1994) and Larsen and Resnick (1998) studied the tracking error as the dispersion of the fund´s NAV return relative to the benchmark return and identified three metrics to measure it. In turn, Harper et al. (2006) found out that tracking error can be calculated using market prices instead of the NAV (Harper et al., 2006).

If using market price to evaluate the tracking error, through in-kind and in-cash creation/redemption processes should disappear quickly any market-price deviations from NAVs (Elton et al., 2002; Engle and Sarkar, 2006). However, the NAV tracking error and the market price tracking error can significantly deviate from each other. In their study, Defusco, Ivanov, and Karels (2011) looked out for example spiders, which track the S&P 500 and got results showing that the pricing deviations are different from zero. One explanation of the authors was that the pricing deviation can take as additional cost of managing an ETF.

There have also been discovered seasonal patterns and geographical differences on tracking errors. First Frino and Gallagher (2001) and then Rompotis (2010) detected seasonal patterns. Frino and Gallagher for instance find that namely tracking error is higher in January and May and lowest in June. Furthermore, Chu (2011) finds that the tracking errors in Hong Kong traded ETFs are higher compared with those in the US and Australia. According to Chu, reason for the higher tracking errors could be the synthetic replication on the ETFs: use of synthetic investment tools instead of holding the underlying stocks. Another 2010s study investigates the tracking error of ETFs and European index funds as measured by their underperformance against the gross total return indices (Blitz, Huij, Swinkels, 2010). Results were that European funds underperform their benchmarks and that fund expenses and dividend withholding taxes have similar explanatory power.

2.3 Hypotheses

In this research, I have divided my hypotheses into two parts. Tracking error is the difference between the returns of an ETF and the target benchmark index, which it is tracking. However, the underlying benchmark index and the ETF returns is not guaranteed to be identical because the index is not facing the similar market frictions than the ETF. Besides in the previous studies, the magnitude of the tracking error has been calculated for example in the US, Australia and China for ETFs and index funds (see e.g. Elton et al., 2002; Frino & Gallagher, 2001 and 2002); Chu, 2011). They have all found evidence of notable tracking error numbers, which mean that their measured values differentiate from zero significantly. Considering the early findings, I expect to find significant tracking error numbers too from the ETFs that track main stock indices of the European countries.

Furthermore, other studies discuss that large ETFs because of the economies of scale should have lower trading costs. Thus, lower tracking errors as well. (see for example Poterba and Shoven, 2002; Kostovetsky, 2003). According to Chu (2011), the size of an ETF is negatively related to the magnitude of the tracking error but positively related to the total expense ratio. Given that total expense ratio is usually higher for small ETFs I test the following hypotheses:

1) There is no significant magnitude of tracking error in the European exchange-traded funds.
2) The size does not affect the value of tracking error.

So the difference in means between the small and large ETFs is not significantly different from zero.

3. Data and Methodology

3.1 Data Sample

The sample analyzed in this paper consists of equity index ETFs that are listed in Europe. At the moment there are total of 1571 ETFs according to ETFGI database at the end of October 2016. For the purposes and the limited amount of time to do the study I chose ETFs that track European stock indices, both major and minor sizes. To make sure a significant data history I selected only ETFs that were created before October 2008 to allow a proper period of sample history. In the past, a common time to research tracking errors has been four years but thanks to rapid growth of the ETF sector, I have enough ETFs to analyze longer period of time starting with October 2008 and ending in September 2016. Thus, I was able to study further about time variation of tracking errors. Although, this eight-year period is necessarily a trade-off between a meaningful data history and significant number of both small and large index ETFs. Especially small sizes from the leading providers of ETFs in Europe.

The final sample includes 35 ETFs that track 15 different benchmark indices: 17 ETFs are from the major indices ETFs and 18 are from the minor. I got the subsamples simply by dividing the total sample into big and small ETFs. Providers construct from Blackrock (iShares), Societe Generale (lyxor), Deutsche Bank (db x-trackers), BBVA, XACT, Seligson, Amundi, UBS and Credit Suisse. The inception date, as well as the primary listing is from the Thomson Datastream. Other characteristics are acquired from the fund prospectuses of the ETF providers. The funds are domiciled in Germany, Ireland, Spain, Switzerland, Ireland, France, Finland, Sweden, Norway and Luxembourg. While this sample is one of the most diverse for ETFs in the academic literature in terms of the benchmark indices and the providers included, this sample is also one of the longest data history to examine the tracking errors. Table 1 reports the profiles of the 35 ETFs, including the name, assets under management (AUM), primary listing, inception date, domicile, use of profits, target benchmark index and total expense ratio (TER).

Table 1: Sample of Exchange-Traded Funds

ETF	Name	AUM (€m)	Primary listing	Inception date	Market	Use of profits	Index	TER
1	ISHARES ATX (DE)	52	Xetra	22.5.2006	Germany	Distributing	ATX	0,32
2	LYXOR ETF CAC 40	3556	Euronext	13.12.2000	France	Distributing	CAC 40	0,25
3	AMUNDI ETF CAC 40	714	Euronext	28.2.2003	France	Distributing	CAC 40	0,25
4	BNP PARIBAS EASY CAC 40	200	Euronext	7.3.2005	France	Distributing	CAC 40	0,25
5	COMSTAGE ETF DAX TR	722	Xetra	21.8.2008	Germany	Accumulating	DAX	0,08
6	DB X-TRACKERS DAX ETF	3698	Stockholm	10.1.2007	Luxembourg	Accumulating	DAX	0,09
7	DEKA DAX UCITS ETF	1675	Xetra	14.3.2008	Germany	Accumulating	DAX	0,15
8	ISHARES DAX (DE)	7679	Xetra	27.12.2000	Germany	Accumulating	DAX	0,16
9	LYXOR DAX (DR) UCITS ETF EUR	948	Xetra	1.6.2006	Luxembourg	Distributing	DAX	0,15
10	ETFLAB EURO STOXX 50	993	Xetra	14.3.2008	Germany	Distributing	Euro Stoxx 50	0,15
11	LYXOR EURO STOXX 50	6342	Euronext	19.2.2001	France	Distributing	Euro Stoxx 50	0,20
12	ISHARES DJ STOXX 50	4963	London	3.4.2000	Ireland	Distributing	Euro Stoxx 50	0,35
13	BNP PARI.EASY ESX. 50	908	Euronext	30.3.2001	France	Distributing	Euro Stoxx 50	0,25
14	UBS ETF DJ ER.STOXX(SWX) 50 A	735	SIX Swiss	29.10.2001	Luxembourg	Distributing	Euro Stoxx 50	0,15
15	ISHARES STOXX EUROPE	633	Euronext	3.4.2000	Ireland	Distributing	Stoxx Europe 50	0,35
16	DB X-TRACKERS DJ EURO STOXX 50	4584	Stuttgart	29.8.2008	Luxembourg	Accumulating	Euro stoxx 50	0,09
17	LYXOR ETF FTSE MIB	750	Milan	11.12.2003	France	Distributing	MIB	0,35
18	DB X-TRACKERS FTSE MIB	123	Stuttgart	4.1.2007	Luxembourg	Distributing	MIB	0,30
19	ISHARES FTSE MIB	427	London	6.7.2007	Ireland	Distributing	MIB	0,35
20	ISHARES AEX	342	London	18.11.2005	Ireland	Distributing	AEX	0,30
21	SPDR AEX ETF	41	Euronext	30.4.2001	Ireland	Distributing	AEX	0,30
22	XACT OBX	146	Oslo	7.4.2005	Norway	Accumulating	OBX	0,30
23	DNB NOR OBX	113	Oslo	1.3.2005	Norway	Accumulating	OBX	0,31
24	LYXOR ETF IBEX 35	651	Madrid	3.10.2006	Spain	Distributing	IBEX	0,30
25	BBVA ACCION IBEX 35 ETF	228	Madrid	7.10.2006	Spain	Distributing	IBEX	0,33
26	XACT OMX	1018	Stockholm	30.10.2000	Sweden	Accumulating	OMXS	0,10
27	ISHARES SMI ETF	2284	SIX Swiss	15.3.2001	Switzerland	Distributing	SMI	0,35
28	UBS FUND MAN.SWITZ. ETF SMI	1309	SIX Swiss	2.12.2003	Switzerland	Distributing	SMI	0,20
29	ISHARES FTSE 100 UCITS ETF	4898	London	27.4.2000	Ireland	Distributing	FTSE 100	0,07
30	UBS-ETF FTSE 100	140	Stuttgart	31.10.2001	Luxembourg	Distributing	FTSE 100	0,20
31	ISHARES FTSE EUROFIRST	39	London	19.10.2001	Ireland	Distributing	FTSE Eurofirst 100	0,40
32	LYXOR ETF FTSE 100	845	London	15.5.2007	France	Accumulating	FTSE 100	0,15
33	ISHARES FTSE 250 UCITS ETF	1027	London	26.3.2004	Ireland	Distributing	FTSE 250	0,40
34	DB X-TRACKERS FTSE 250 ETF	116	London	15.6.2007	Luxembourg	Accumulating	FTSE 250	0,35
35	OMXH25 INDEX SHARE ETF	179	Helsinki	8.2.2002	Finland	Accumulating	OMXH 25	0,17

This table reports the name, the assets under management (in millions euros), the primary listing, the inception date, the market focusing on, whether the ETF is distributing or accumulating it`s dividends, the benchmark index which it is tracking and the total expense ratio (TER) of each ETF included in the sample.

The time-series data of the ETFs and their benchmark indices is taken from the Thomson Datastream. I have used total return index for to describe the theoretical growth in value of an ETF and its benchmark for the length of eight-year period. It assumes that dividends are re-invested to purchase additional unit trusts for using closing bid price on the ex-dividend date. The dividends in the total return index are gross of taxes, which makes the return data more comparable since some ETFs do not distribute dividends to avoid taxes paid, whereas some do distribute them. After that, I calculate the returns simply by deducting the previous amount of the total return index for the current amount and dividing the difference for the size of the previous amount, as follows:

$$r_t = \frac{(TRI_t - TRI_{t-1})}{TRI_{t-1}}$$

3.2 Methodology

Generally, tracking error is calculated by the ETF providers as the return difference between ETF´s NAV and the underlying index or as the standard deviation of the return differences over time. Previous researches in the academic literature recognize four different measures of tracking error: three of them focus on the deviation of the ETF returns relative to the returns of the benchmark and one calculate the mean of the return differences. (see e.g. Frino & Gallagher, 2002; Elia, 2012.) In this study, I follow the methods what they have used, hence replicating them. I also use the same equation form than Elia (2012) for simplicity.

3.2.1. Tracking Error Measures

The first measure of the tracking error what I am following is the mean of the monthly return differences ($TE_{RD,i}$) between the ETF i and the benchmark index b (Frino and Gallagher, 2002; Harper, Madura, and Schnusenberg, 2006; Elia, 2012). It can be a positive or a negative number. This measure is especially for those investors whose first interest is to focus on the difference between the return of the ETF and the return of the index (Elia, 2012). It is defined as:

$$TE_{RD,i} = \frac{\sum_{t=1}^{n} R_{i,t} - R_{b,t}}{n} \quad (1)$$

where $R_{i,t}$ is the NAV return of the ETF i in month t, $R_{b,t}$ is the return of the benchmark index b in month t and n is the number of months.

Before that, Roll (1992), Pope and Yadav (1994) and Larsen and Resnick (1998) had identified three other methods for measuring tracking errors. These methods point out the variability of the

monthly over- or under-performance of the ETF relative to its benchmark index. Equation (2) is the average of the absolute differences in the returns between the ETF I and the benchmark index b ($TE_{AAD,i}$) and it always gives positive numbers. (Elia, 2012). It is counted as follows:

$$TE_{AAD,i} = \frac{\sum_{t=1}^{n} |R_{i,t} - R_{b,t}|}{n} \quad (2)$$

where the variables are defined as above.

Equation (3) gives the tracking error counted as the standard deviation of the return differences ($TE_{SDRD,i}$) and defined as follows:

$$TE_{SDRD,i} = \sqrt{\frac{1}{n-1} \sum_{t=1}^{n} (RD_{i,t} - \overline{RD_i})^2} \quad (3)$$

The well-known market model can also generate an estimate of tracking error. The last equation (4) is the standard error of a regression of ETF returns on benchmark returns. The returns on the ETF fund i ($R_{i,t}$) are regressed on the returns on the benchmark index b ($R_{b,t}$). In other words, if the ETF fund i ($R_{i,t}$) is the dependent variable and the return of the benchmark b ($R_{b,t}$) is the independent variable, as follows:

$$R_{i,t} = a_j + B_j R_{b,t} + e_{i,t} \quad (4)$$

the standard error of the regression equation (the volatility of residuals ($e_{i,t}$) around the regression line) represents an estimate of tracking error. (Frino and Gallagher, 2002). According to Frino and Gallagher (2002) this measure should provide similar results than equation (2). However, Pope and Yadav (1994) note that if the beta of a portfolio is not exactly equal to one, then the tracking error metric (TE_{SDRD}) will differ from the regression residuals. This means that if the two sets of return relationship is non-linear, then this method will overstate tracking error.

Every metrics used here to calculate the tracking error measure the ETF NAV return divergences from the underlying index. According to Elia (2012), the NAV tracking error gauges how well the ETF managers do their jobs. In other words, the ability of the ETF managers to track the benchmark

index. Although there is another way to measure the tracking error. Elton et al. (2002), Harper et al. (2006) and DeFusco et al. (2011) use in their researches market prices of the ETFs instead of their NAV. Some researches analyze the return deviations based on both measures: Charupat and Miu (2011) calculate the tracking error of leveraged ETFs by using NAV and market prices.

Monthly returns are used to calculate the four tracking error measures following thus Roll (1992), Frino and Gallagher (2001) and Elia (2012). This is because higher frequency data can cause overestimation of tracking error since high-frequency such as daily or weekly data might create negative serial correlation between ETF's and its benchmark's return differences (Pope and Yadav, 1994; Elia, 2012).

3.2.2 Bias Measures

According to Frino & Gallagher (2002) the methods above measure the efficiency with which in this case ETFs are able to track their target benchmark indexes. They do not indicate if the ETF is systematically underperform (or outperform) its benchmark index. Thus, it neither describes if there is a bias in performance. Nonetheless, there are two measures which can evaluate that. The first is the standard deviation, which is a traditional measure to estimate the efficiency and while the mean value can be used to determine bias. Second, given that the ETF's objective is to replicate the performance of its target benchmark index, the coefficient α in the equation 4 (TE_{SDRD}) is expected to be zero and at the same time $\beta = 1$. Hence, if there is a significant α coefficient in the sample, it is proof of bias in tracking error as well. (Frino & Gallagher, 2002.)

4. Results

4.1 The Magnitude of Tracking Error

The tracking error of each index ETF is evaluated in Table 2 together with a number of other descriptive statistics like mean, standard deviation, minimum and maximum values. Table 2 reports the magnitude of tracking error for the entire sample period since October 2008 to the end of September 2016 total 96 months (eight years) available for each ETF. Based on TE_{AAD} the magnitude of monthly tracking error ranges from an average of 0,001 percentage to 0.049 per cent across ETFs. There is some time variability of tracking error to be seen for each ETF as well for example Ishares Dj Stoxx 50 ranges between 0,069 percentages and 0,489 per cent across months.

Taken into account that the tracking error metrics are comparable since the sample period is the same for all ETFs, it is notable magnitude of tracking error for that ETF. The monthly tracking error based on measure TE_{SDRD} ranging 0,002% to 0,078% for all ETFs in the sample with whole period of research and thus is similar in magnitude . In addition, standard error of residuals (TE_{SER}) values is nearly identical to those tracking error numbers reported with measure TE_{SDRD}.

If comparing in the past, e.g. documented values in US has been (0,039% and 0,110% per month) and Australia (0,074% and 0,224% per month) according to measure TE_{AAD} (Frino & Gallagher, 2001, 2002). Chu (2011) has studied ETFs traded in Hong Kong and got results considerably higher (0,2786% and 2,1736%). However, they are not directly comparable since Chu uses in his study daily returns instead of monthly data. This means that these equity index ETFs have been tracked their benchmark indexes quite accurately and the numbers are modest compared to previous studies.

Even though the magnitude of the tracking errors reported in the Table 2 is small, still many perceptions can be drawn. First, in the Australian research pointed out that there is higher cost of trading the underlying portfolio of stocks when the passive funds managers have to make changes on their index composition (Frino & Gallagher, 2002). Second, during the last decade the average total expense ratio (TER) of ETFs has decreased measurably (Morningstar, 2014) [4]. Considering the fact that according to Morningstar (2013) over 50% of the tracking error could be explained by its total expense ratio[5]. When calculating the monthly TERs (by dividing the annual TER for amount of months) from the sample we see that monthly TER varying between 0,006 to 0,033 per cent. This indeed means that there is more tracking error than the size of expense ratio but analysis from the factors, which it might consist of, is out of this study.

According to TE_{SER} measure which is the standard error of the residuals of the return regression, there is no evidence of significant bias in performance. For example, the estimated α coefficients are negligible in magnitude and do not differentiate from zero significantly for any of the ETFs on

[4] Based on Morningstar Manager Research. December 2014. http://global.morningstar.com/us/documents/pr/Cost-Of-Owning-Index-ETF-MFS.pdf

[5] Morninstar ETF Research. February 2013. http://media.morningstar.com/uk/MEDIA/Research_Paper/Morningstar_Report_Measuring_Tracking_Efficiency_in_ETFs_February_2013.pdf

the sample period. Also the mean difference in returns is negligible and not significant based on standard t-tests.

Table 2 shows that there are a few ETFs, which seems to have statistical significant magnitude of tracking error. However, overall Table 2 reports a clear evidence that in this sample of ETFs there is no systematic statistical significant magnitude of tracking errors throughout the entire eight-year sample period. From the viewpoint of investors, this proves that European equity index ETFs provide fully efficient tracking of the underlying index.

Table 2: Tracking Error Magnitude of ETFs in the Sample

	(Teadd) Absolute difference on returns								Differences in returns (Tesdrd)				(Teser) Market model parameters					
ETF	N	Mean	SD	Min	Q1	Q2	Q3	Max	Mean	t-stat		SD	SE Reg.	a	t-stat		B	R^2
ETFs since October 2008 to the end of September 2016 (monthly data)									(Terd)									
ISHARES ATX (DE)	96	0,005	0,008	0,000	0,002	0,004	0,006	0,054	-0,001	-0,65		0,009	0,009	-0,001	-0,61		0,966	0,983
LYXOR ETF CAC 40	96	0,001	0,002	0,000	0,000	0,001	0,002	0,009	0,000	-1,46		0,002	0,002	0,000	-1,53		0,994	0,999
AMUNDI ETF CAC 40	96	0,002	0,009	0,000	0,000	0,000	0,000	0,060	0,000	-0,16		0,009	0,009	0,000	-0,11		0,993	0,973
BNP PARIBAS EASY CAC 40	96	0,002	0,002	0,000	0,000	0,001	0,002	0,009	0,000	-0,70		0,003	0,003	0,000	-0,55		0,997	0,997
COMSTAGE ETF DAX TR	96	0,004	0,010	0,000	0,001	0,002	0,004	0,096	0,001	0,77		0,011	0,005	0,000	-0,47		1,018	0,992
DB X-TRACKERS DAX ETF	96	0,004	0,004	0,000	0,001	0,003	0,004	0,026	0,000	-0,24		0,005	0,005	0,000	-0,57		1,016	0,993
DEKA DAX UCITS ETF	96	0,006	0,006	0,000	0,001	0,003	0,008	0,026	0,000	-0,02		0,008	0,009	0,000	0,07		0,986	0,980
ISHARES DAX (DE)	96	0,004	0,004	0,000	0,001	0,002	0,004	0,024	-0,001	-1,09		0,005	0,005	-0,001	-1,39		1,018	0,993
LYXOR DAX (DR) UCITS ETF	96	0,004	0,004	0,000	0,001	0,003	0,005	0,024	0,000	-0,44		0,006	0,005	-0,001	-0,90		1,022	0,993
ETFLAB EURO STOXX 50	96	0,007	0,008	0,000	0,002	0,004	0,008	0,034	0,000	-0,25		0,011	0,011	0,000	-0,09		0,971	0,965
LYXOR EURO STOXX 50	96	0,001	0,002	0,000	0,000	0,001	0,002	0,007	-0,001	-2,94	***	0,002	0,002	-0,001	-3,09	***	0,995	0,999
ISHARES DJ STOXX 50	96	0,049	0,061	0,000	0,008	0,033	0,069	0,489	-0,002	-0,27		0,078	0,003	0,000	-1,14		0,991	0,998
BNP PARI.EASY ESX. 50	96	0,047	0,036	0,004	0,020	0,036	0,064	0,148	-0,004	-0,67		0,059	0,010	0,000	-0,50		0,964	0,971
UBS ETF DJ ER.STOXX 50	96	0,020	0,022	0,000	0,006	0,012	0,026	0,143	-0,004	-1,39		0,029	0,016	0,001	0,49		0,774	0,895
ISHARES STOXX EUROPE	96	0,004	0,004	0,000	0,001	0,003	0,005	0,031	0,000	-0,77		0,006	0,006	0,000	-0,68		0,987	0,985
DB X-TRACKERS DJ EURO STOXX 50	96	0,004	0,004	0,000	0,001	0,003	0,005	0,021	-0,001	-1,22		0,005	0,008	-0,003	-3,33	***	-0,961	0,982
LYXOR ETF FTSE MIB	96	0,003	0,004	0,000	0,001	0,001	0,003	0,028	-0,001	-1,55		0,005	0,005	-0,001	-1,41		0,980	0,996
DB X-TRACKERS FTSE MIB	96	0,007	0,012	0,000	0,002	0,004	0,007	0,096	-0,001	-0,45		0,014	0,013	0,000	-0,32		0,930	0,960
ISHARES FTSE MIB	96	0,021	0,019	0,000	0,008	0,017	0,029	0,134	0,000	0,16		0,029	0,029	0,001	0,23		0,977	0,850
ISHARES AEX	96	0,020	0,020	0,000	0,006	0,015	0,028	0,132	0,000	0,15		0,028	0,028	0,001	0,43		0,922	0,765
SPDR AEX ETF	96	0,002	0,004	0,000	0,000	0,001	0,002	0,031	0,000	-0,88		0,004	0,004	0,000	-0,98		1,008	0,995
XACT OBX	96	0,005	0,006	0,000	0,001	0,002	0,007	0,032	0,000	-0,47		0,008	0,008	0,000	-0,45		0,977	0,983
DNB NOR OBX	96	0,003	0,003	0,000	0,001	0,002	0,004	0,016	0,000	-1,01		0,005	0,004	0,000	-0,59		0,985	0,994
LYXOR ETF IBEX 35	96	0,022	0,027	0,000	0,002	0,012	0,035	0,113	-0,004	-1,20		0,035	0,030	-0,003	-0,97		0,713	0,713
BBVA ACCION IBEX 35 ETF	96	0,007	0,012	0,000	0,001	0,002	0,005	0,069	-0,003	-2,07	**	0,014	0,013	-0,003	-1,87	**	0,952	0,957
XACT OMX	96	0,003	0,005	0,000	0,001	0,002	0,003	0,048	-0,001	-1,21		0,006	0,006	-0,001	-1,09		0,993	0,985
ISHARES SMI ETF	96	0,003	0,003	0,000	0,001	0,002	0,004	0,023	-0,001	-1,40		0,005	0,004	0,000	-0,94		0,964	0,988
UBS FUND MAN.SWITZ. ETF SMI	96	0,002	0,003	0,000	0,001	0,001	0,003	0,020	0,000	-0,79		0,004	0,004	0,000	-0,48		0,987	0,991
ISHARES FTSE 100 UCITS ETF	96	0,002	0,004	0,000	0,001	0,001	0,003	0,031	0,000	-0,63		0,005	0,005	0,000	-0,51		0,991	0,987
UBS-ETF FTSE 100	96	0,022	0,029	0,000	0,008	0,016	0,028	0,236	-0,001	-0,25		0,036	0,034	0,001	0,40		0,670	0,436
ISHARES FTSE EUROFIRST	96	0,006	0,006	0,000	0,002	0,004	0,008	0,037	0,000	0,68		0,005	0,009	-0,002	-1,75	**	0,999	0,972
LYXOR ETF FTSE 100	96	0,002	0,003	0,000	0,001	0,001	0,002	0,022	0,000	-0,64		0,004	0,004	0,000	-0,30		0,977	0,992
ISHARES FTSE 250 UCITS ETF	96	0,004	0,003	0,000	0,002	0,003	0,005	0,016	0,000	-0,69		0,005	0,004	-0,001	-1,09		1,005	0,992
DB X-TRACKERS FTSE 250 ETF	96	0,020	0,021	0,000	0,006	0,012	0,030	0,143	-0,001	-0,32		0,029	0,029	0,000	0,01		0,895	0,696
OMXH25 INDEX SHARE ETF	96	0,010	0,011	0,000	0,003	0,005	0,013	0,047	0,004	-2,76	***	0,014	0,014	0,004	2,84	***	1,023	0,948

The table reports tracking error metrics for all equity index exchange-traded funds used in the study from the September 2008 to October 2016 and using monthly data only. All metrics are expressed in percentage terms. N represents the number of observations for each exchange-traded fund used in the analysis.

4.2 Tracking Error Difference of Two Subsamples

Table 3 documents the median, mean, minimum, maximum tracking errors yearly and for the whole eight-year sample period. Year 1 responds to the period from October 2008 to September 2009 and year 8 is the period from October 2015 to September 2016. Panel A includes every ETFs in the sample, Panel B ETFs which hold assets under management over 750 million euros and Panel C ETFs holding under 750 million euros. Final two columns of the table show the difference in the mean values between the ETFs over and under 750 AUM and t-statistics. TE_{RD} which is the monthly return differences ranges from -0,028 per cent to 0,025 with an average of -0,001 percentage across all of the ETFs in the sample. Yearly studies report that there is variability through time. TE_{RD} also proves the underperformance of the ETFs relative to the index, which is quite rational e.g. because of TER and other factors affecting the size of tracking error as mentioned earlier.

In view of the other measures, the mean of the tracking error through sample period (TE_{AAD}) calculated as the average of the monthly absolute differences between the return of the ETF and the return of the benchmark index is 0,012% on average ranging between 0,004% to 0,036%. Standard deviation of the return differences (TE_{SDRD}) and the standard error of the residuals of the return regression (TE_{SER}) is on average of 0,024% and 0,009% and they ranges between 0,007% to 0,088% and 0,000% to 0,078% respectively.

Considering again the tracking error number reported in US and Australia my numbers are much lover level as expected when comparing each ETF separately and with the full sample. Further, Elia (2012) has reported tracking error values for European synthetic and traditional replication methods using exchange-traded funds. His tracking error numbers were as well a bit higher than what I got. For example, his TE_{AAD} value is 0,080% and TE_{SDRD} 0,100% on average respectively. There are a few explanations which might have cause on that. This difference can be partially explained by the fact that Elia`s sample period ends 2012 and after that ETF sector has grown rapidly both in case of assets and the number of ETFs. More competitive markets and higher trading volumes per day put the pressure for ETF managers trying to minimize the tracking error value as low as possible. Furthermore, Elia calculates the tracking error measured by the mean of the return differences using both the net and the gross total return of the benchmark index. Thus, he can

evaluate the impact of dividend taxes on ETF performance. However, I use only gross total returns and hence could end up with different results. Also he has distinct ETFs in his sample and the total expense ratio has decreased significantly since past decade as mentioned before.

Panel B and Panel C split the full sample into small and large ETFs based on the size of assets under management. According to measures of the tracking error there is no significant evidence of the difference in means for ETFs with larger AUM or vise versa. This preliminary results show that the tracking error do not differentiate significantly between small or large ETFs in any given time during sample period neither with any measures of tracking error. Thus, there is evidence that ETF`s asset under management size should not matter for ETF`s ability to track the benchmark index what it is following.

Table3: Summary Statistics

	Panel A: Full sample				Subsamples									
					Panel B: ETFs over 750M AUM				Panel C: ETFs under 750M AUM				Difference in	
	Median	Mean	Min	Max	Median	Mean	Min	Max	Median	Mean	Min	Max	the means	t-stat
	1	2	3	4	5	6	7	8	9	10	11	12	(6-10)	
Terd overall	-0,001	-0,001	-0,028	0,025	-0,001	-0,001	-0,042	0,022	-0,002	-0,001	-0,029	0,027	0,000	0,03
Year1	0,001	-0,001	-0,028	0,025	0,001	-0,002	-0,042	0,022	0,000	0,000	-0,029	0,027	-0,002	-0,08
Year2	0,001	-0,001	-0,015	0,006	0,000	-0,001	-0,015	0,007	0,000	-0,001	-0,015	0,007	0,000	0,02
Year3	0,000	0,001	-0,005	0,013	0,001	0,002	-0,007	0,015	0,000	0,001	-0,005	0,012	0,001	0,14
Year4	-0,002	-0,003	-0,014	0,009	-0,003	-0,002	-0,015	0,008	-0,002	-0,003	-0,014	0,011	0,001	0,05
Teaad overall	0,010	0,012	0,004	0,036	0,008	0,009	0,002	0,043	0,012	0,014	0,005	0,054	-0,006	-0,53
Year1	0,025	0,024	0,009	0,036	0,019	0,020	0,005	0,043	0,029	0,027	0,010	0,054	-0,007	-0,44
Year2	0,010	0,011	0,006	0,018	0,009	0,009	0,003	0,016	0,012	0,013	0,009	0,020	-0,004	-0,90
Year3	0,011	0,011	0,005	0,020	0,007	0,009	0,004	0,018	0,013	0,014	0,005	0,023	-0,005	-0,41
Year4	0,012	0,012	0,006	0,019	0,010	0,010	0,004	0,018	0,014	0,013	0,007	0,021	-0,003	-0,46
Tesdrd overal	0,020	0,024	0,007	0,088	0,014	0,018	0,002	0,122	0,022	0,028	0,007	0,084	-0,009	-0,41
Year1	0,049	0,048	0,015	0,088	0,038	0,042	0,007	0,122	0,054	0,050	0,015	0,084	-0,008	-0,23
Year2	0,020	0,022	0,011	0,046	0,014	0,016	0,004	0,033	0,024	0,026	0,013	0,055	-0,010	-0,73
Year3	0,021	0,023	0,007	0,049	0,015	0,018	0,006	0,041	0,026	0,027	0,007	0,055	-0,009	-0,51
Year4	0,023	0,025	0,009	0,046	0,020	0,022	0,007	0,050	0,027	0,027	0,010	0,050	-0,005	-0,29
Teser overall	0,005	0,009	0,000	0,078	0,004	0,005	0,001	0,021	0,009	0,012	0,000	0,078	-0,007	-0,56
Year 1	0,011	0,014	0,000	0,054	0,009	0,003	0,008	0,021	0,016	0,019	0,000	0,054	-0,016	-0,92
Year 2	0,006	0,008	0,000	0,025	0,005	0,001	0,004	0,013	0,009	0,011	0,000	0,025	-0,010	-1,09
Year 3	0,005	0,007	0,000	0,022	0,004	0,001	0,003	0,011	0,007	0,010	0,000	0,022	-0,009	-1,15
Year 4	0,007	0,009	0,001	0,029	0,007	0,001	0,006	0,017	0,009	0,012	0,001	0,027	-0,011	-1,20

Table3: (Continued)

	Panel A: Full sample				Subsamples									
					Panel B: ETFs over 750M AUM				Panel C: ETFs under 750M AUM				Difference in	
	Median 1	Mean 2	Min 3	Max 4	Median	Mean	Min	Max	Median	Mean	Min	Max	the means (6-10)	t-stat
Terd overall														
Year5	-0,001	-0,002	-0,011	0,003	-0,001	-0,002	-0,009	0,004	-0,002	-0,003	-0,013	0,002	0,001	0,15
Year6	-0,001	-0,001	-0,008	0,009	-0,001	0,000	-0,007	0,009	-0,002	-0,002	-0,010	0,009	0,002	0,24
Year7	0,000	-0,001	-0,013	0,014	0,001	0,000	-0,009	0,007	0,000	-0,001	-0,016	0,019	0,000	0,02
Year8	-0,001	-0,001	-0,013	0,009	-0,001	0,000	-0,008	0,007	-0,002	-0,001	-0,017	0,011	0,000	0,01
Teaad overall														
Year5	0,007	0,008	0,005	0,016	0,005	0,006	0,002	0,011	0,009	0,011	0,005	0,021	-0,005	-0,94
Year6	0,008	0,008	0,005	0,011	0,006	0,006	0,002	0,011	0,009	0,009	0,005	0,013	-0,003	-0,81
Year7	0,008	0,010	0,005	0,021	0,006	0,007	0,003	0,011	0,010	0,013	0,006	0,030	-0,007	-0,80
Year8	0,007	0,010	0,004	0,018	0,004	0,004	0,002	0,009	0,010	0,014	0,006	0,027	-0,009	-1,17
Tesdrd overall														
Year5	0,014	0,017	0,009	0,033	0,010	0,011	0,003	0,024	0,017	0,021	0,011	0,040	-0,010	-0,79
Year6	0,015	0,015	0,008	0,025	0,011	0,012	0,002	0,025	0,018	0,017	0,009	0,026	-0,005	-0,53
Year7	0,016	0,021	0,009	0,052	0,011	0,014	0,005	0,031	0,019	0,026	0,011	0,065	-0,011	-0,60
Year8	0,014	0,020	0,008	0,048	0,007	0,010	0,002	0,030	0,019	0,025	0,010	0,059	-0,016	-0,88
Teser overall														
Year 5	0,004	0,008	0,000	0,045	0,003	0,003	0,001	0,008	0,007	0,011	0,000	0,034	-0,010	-1,39
Year 6	0,005	0,011	0,000	0,078	0,003	0,003	0,001	0,008	0,010	0,015	0,000	0,078	-0,014	-1,24
Year 7	0,004	0,006	0,000	0,024	0,003	0,003	0,001	0,005	0,006	0,008	0,000	0,024	-0,007	-0,36
Year 8	0,004	0,007	0,000	0,025	0,003	0,003	0,001	0,007	0,006	0,010	0,000	0,025	-0,008	-0,58

These tables documents summary information on the sample of ETFs. Terd is the tracking error measured by the mean of the monthly return differences between the ETF and the benchmark index. Teadd is the average of the absolute differences in the returns; tesdrd is the standard deviation of the return differences; and teser is the standard error of the residuals of the return regression. Tracking error metrics are calculated using monthly data over the entire sample period (October 2008 to September 2016) and yearly. Panel A concludes all of the ETFs in the sample, Panel B includes only the ETFs that holds asset under management (AUM) over 750 million and Panel C comprises ETFs under 750 million AUM. The last two columns report the difference in the means of the tracking error for ETFs over and under 750m AUM and t-statistics. All trackin error metrics are described in percentage terms.

5. Conclusion

Exchange-traded funds have grown in investor´s popularity since their first appearance in American Stock Exchange year 1993. This thesis examines the magnitude of tracking errors in the European listed equity ETFs by each ETF separately and with full sample focusing mostly on the main stock indices of the European countries. Yet this study investigates the tracking error differences among two subsamples based on the size of the ETF using assets under management as a criterion. This is probably the first study to examine the magnitude of tracking errors and the tracking error differences based on ETF´s size from the European market throughout the time since October 2008 to September 2016.

I find out that the magnitude of the tracking error of European ETFs using monthly data are comparatively lower than what have been previously found in US, Australia, China and European markets. Further, I find that a few of the ETFs have had a significant magnitude of tracking error but overall there are no systematic evidence of the magnitude of tracking error to be found throughout the sample period. In the second part of my research I find no evidence that tracking errors differentiate between small and big size ETFs, which contradicts a bit from the previous literature. Finally, my findings imply that tracking error has decreased during this eight-year observation period.

My results suggest that European ETFs provides fully efficient tracking of their underlying benchmark indices. Besides they mean that larger ETFs could not produce smaller tracking errors than smaller size ETFs. On the contrary to what I expected, larger ETFs should have lower transaction cost in trading stocks due to the economies of scale and this produces lower tracking errors for larger size of funds. Results are partly explained by ETF´s decreased average total expense ratio during the last decade and the rapid growth of the ETF sector. From the investors' point of view, European ETF markets are rather competitive and hence investors could easily find fully efficiently stock indices tracking ETFs, which minimize the tracking error. At the moment European ETF managers are able to offer nearly similar returns than their underlying investment target at least in case of stock index ETFs.

For the future research it would be interesting to test with different asset classes if there are same results expected to come than with stock index ETFs and purely stock indices itself is interesting to investigate more widely, e.g. globally. Furthermore, European markets include several hundreds

of ETFs and thus expanding the research to larger sample but shorter time period would be as well worthwhile to examine.

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Appendix 1: Average Monthly Tracking Difference

Figure 2 visualizes how average return of the whole sample of ETFs differ from their benchmark indices on a monthly basis. Most of the time tracking differences seem to been near to zero but it looks like that the tracking difference spikes have been during both financial crises 2008 and 2012. Through observation period the spread has tighten as well. Yet figure 2 shows that exchange-traded funds, which track stock indices of the European countries seem to quite efficiently follow their target benchmark indices

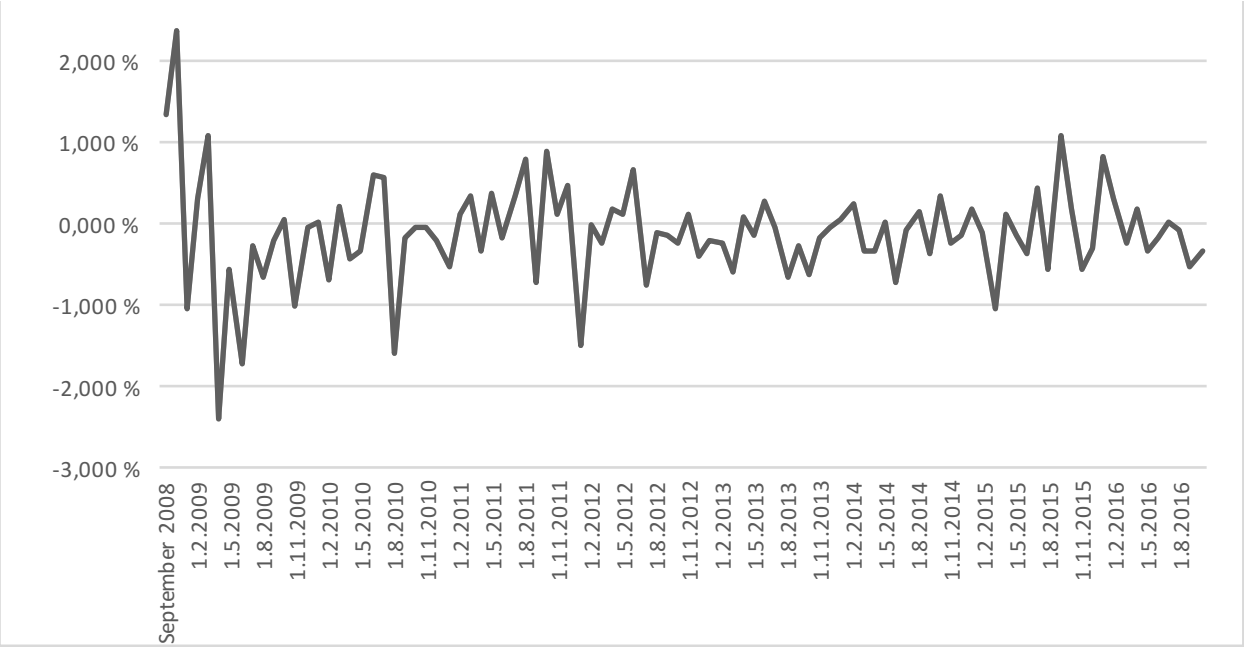

Figure 2. Spread between the average ETF return and the target benchmark index.

Appendix 2 Four-Year Comparison

Table 4 gives further evidence about time variation in tracking errors. I split the sample period into two four-year time period to examine if there was difference in the tracking errors between the times 2008-2012 and 2012-2016. I calculated median, mean, minimum and maximum values using four tracking error measures. Results suggest that this in-depth analysis offers further proofs that during this sample period the tracking errors and tracking differences have decreased.

Table 4. Four-Year Comparison

	Median	Mean	Min	Max
(Terd)				
2008-2012	0,000	-0,001	-0,028	0,025
2012-2016	-0,001	-0,001	-0,013	0,014
(Teadd)				
2008-2012	0,012	0,015	0,005	0,036
2012-2016	0,008	0,009	0,004	0,021
(Tesdrd)				
2008-2012	0,024	0,030	0,007	0,088
2012-2016	0,015	0,018	0,008	0,052
(Teser)				
2008-2012	0,007	0,010	0,000	0,054
2012-2016	0,004	0,008	0,000	0,078

This table presents the four-year comparison of the whole sample of ETFs. Both periods consits of 48 months from which are calculated median, mean minimum and maximum tracking error values.